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2 of 2 The Patent Office
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1. Your reference

MRH.P04421GB/P274GB1

2. Patent application number
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21 SEP 2000 0023268.6

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Johnson Electric S.A.
Rue Fritz-Courvoisier 40
CH2300 La Chaux-de-Fonds
Switzerland

Patents ADP number *(if you know it)*

04018313005

If the applicant is a corporate body, give the country/state of its incorporation

Switzerland

22SEP00 E570366-1 002896
P01/7700 0.00-0023268.6

4. Title of the invention

ELECTRIC MOTOR

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

A R Davies & Co
27 Imperial Square
Cheltenham
GL50 1RQ

Patents ADP number *(if you know it)*

570001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
GB	0020418.0	19th August 2000

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
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Yes

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Continuation sheets of this form	
Description	4
Claim*(s)*	2
Abstract	1
Drawing*(s)*	4 + 11

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Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature A.R. Davies   Date

A R Davies & Co   20th September 2000

12. Name and daytime telephone number of person to contact in the United Kingdom
Mr M R Higgins
01242 524520

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Electric Motor

This invention relates to electric motors and in particular, to an electric motor incorporating a speed sensor circuit.

The emphasis on designing electric motors, especially miniature permanent magnet electric motors, has been and continues to be to reduce the size or volume of the motor without loss of power output. However, in the past, as components are added to a motor to improve an aspect of the motor, the size of the motor was increased to accommodate the new component(s). This is particularly evident for speed sensors which are required for servo systems. Speed sensors generally provide a voltage or pulse output whose amplitude or frequency is a function of the speed of the motor. This signal is used by a servo amplifier to control the motion of the motor.

Typical techniques to measure the speed of a motor include adding tacho-generators or frequency generators to the shaft of the motor. These require additions to the motor frame size and thereby increases its bulk. Techniques involving detecting the current peaks in the motor's electrical input have been tried and while moderately successful, involve sensitive electronics which are affected by noisy environments and unclean commutator switching which often occurs with motor wear rendering the sensor inoperative in a worst case scenario.

Accordingly, there is a need for a speed sensor which is less dependent on the input power and which does not increase the bulk or size of the motor.

This is achieved by the present invention by a sensor coil being formed on an inner face of a stator magnet and located in the air gap between the magnet and the rotor.

Thus, the present invention, in one aspect thereof, provides a permanent magnet direct current motor comprising: a permanent magnet stator including at least one permanent magnet; a rotor including a rotor shaft, an armature core mounted on the shaft and having a plurality of poles, an armature winding wound about the poles, and a commutator mounted on the shaft adjacent one end of the armature core and connected to lead wires of the armature winding, the rotor being journaled in bearings and located confronting the stator; and a speed sensor; wherein the speed sensor is a coil of conductive material located in the air gap between the permanent magnet and the armature core.

Preferably, the coil is a single turn coil fixed to an inner face of the magnet facing the armature core.

Preferably, the coil is a single turn coil in the form of a long narrow "U".

Preferably, the terminals of the coil are located on an axial end face of the magnet.

Preferably, the terminals of the coil mate with resiliently deformable fingers or spring biased terminals fixed to the motor end cap. The deformable fingers may be conductive rubber terminals fixed to the end cap.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is an exploded view of a pmdc motor in accordance with the preferred embodiment;

Figure 2 shows a magnet of the motor of Figure 1 supporting a speed sensor coil;

Figure 3 shows a similar magnet supporting a speed sensor coil having a different shape; and

Figure 4 shows a similar magnet supporting a speed sensor coil according to an alternate embodiment.

Figure 1 illustrates a typical pmdc 10 motor modified to incorporate a speed sensor coil 12 according to a first embodiment of the present invention. The motor has a permanent magnet stator having two arcuate ceramic magnets 14. A rotor 16 is located in confronting relationship with the stator magnets 14 and is journaled in bearings 18 fitted to an end cap 20 and a rear housing part 22. The rotor has a shaft 24, armature core 26 and a commutator 28. The armature core 26 is a stack of laminations forming a plurality of salient poles about which coils are wound forming an armature winding 30. The coils are terminated on the commutator 28.

The end cap 20 supports brushes 32 which make sliding contact with the commutator 28 to electrically connect the armature winding 30 to a source of electric power via motor terminals 34. The end cap also supports two spring contacts 36. The spring contacts are resiliently deformable conductive strips which are connected to sensor

terminals 40 on the end cap. Alternatively, the spring contacts could be conductive rubber posts fixed to and extending from the end cap.

One of the two magnets 14 has a conductive coil 12 formed on its radially inner surface which faces the armature core 26 across an air gap such that the coil 12 is in the air gap between the magnet 14 and the armature core. The coil 12 has a conductive U-shaped path forming a single turn. The thus shaped single turn coil starts and finishes at terminal pads 38 on an axial face of the magnet adjacent the end cap. The two spring contacts 36 are arranged to contact the terminal pads to transfer the signal from the coil 12 to external circuitry via the sensor terminals 40 on the end cap 20. The use of spring contacts greatly simplifies construction compared with soldering lead wires directly to the coil on the magnet.

The coil 12, being a single turn coil, is easy to apply without providing insulation between the turns. As such, the coil can be formed from conductive film, conductive foil, conductive tape or wire. In the embodiments described, the coil 12 is formed using conductive ink applied onto the surface of the magnet by a pad printing process. Alternatively, the ink could be applied by painting which is labour intensive or by screen printing but this is more difficult due to the surface of the magnet being curved. If the magnet surface is conductive, a non-conductive coating is needed to insulate the coil from the magnet surface. For ceramic magnets and resin-bonded magnets, this kind of coating is not needed.

Although good results are obtainable using this method as generally described, cleaner signals can be produced using a narrow U-shaped single turn coil 12 formed on the face of the magnet 14 as shown in Figure 3.

A sharper, cleaner signal can be produced using a coil having dimensions which are similar to the dimensions of the slot between the poles of the rotor core. If the "U" is too wide, the signal is not as sharp. If the "U" is too narrow, the amplitude of the signal is not as large making it harder to separate the signal from noise. It is preferred that the orientation of the "U" should correspond with the orientation of the slot. thus normally, the "U" would extend axially but for a motor with a skewed rotor core, the "U" should be similarly skewed.

The location of the coil across the face of the magnet is not critical for generating a good signal. However, the single turn coil also picks up a pulse due to commutation as the brushes slide from one commutator segment to the next. As the timing of the commutation spike is independent of the location of the coil, the location of the coil

can be chosen so that the commutation spike and the speed pulse are separated in time.

In an alternative design, shown in Figure 4, the commutation noise is suppressed by using a narrow "W" shaped coil. This coil acts as two loops connected in parallel. Each loop senses the change in magnetic flux as the armature core rotates causing the slot to pass over each loop in turn producing a sinusoidal type pulse. Each loop also senses the commutation pulse but due to the connection between the loops, the commutation pulse in each loop, being equal but opposite cancel each other.

The W-shaped coil has three terminals. The middle terminal is common to both loops. Indeed, the two loops share a common leg. The other two terminals are connected together to complete the parallel connection. This may be done on the magnet if space permits or between the sensor terminals on the end cap.

Thus, in this design, it can be seen that commutation induces in each loop of the coil equal and opposite electromotive forces at the same point in time, thus effectively canceling each other and hence suppressing commutation noise.

From the above description, it can be seen that sensing the speed of a motor using a speed sensor according to the present invention does not require an increase in the size or bulk of the motor. With the coil 12 located between the magnet and the armature core 26, the magnetic flux passing through the coil varies as the rotor turns from a maximum when a pole is adjacent the coil to a minimum when a slot between the poles is adjacent the coil. The variation in the magnetic flux creates a voltage pulse in the coil and thus, as the rotor rotates, the sensor coil produces a series of pulse signals. By measuring the time between pulses or the frequency of the output signal, the speed of the motor can be determined. This information can then be used in a motor controller for controlling the speed of the motor.

While preferred embodiments have been described in detail, various modifications will be apparent to the skilled addressee without departing from the spirit of the invention and it is intended that all such variations be covered by the invention as defined by the appended claims.

Claims:

1. A permanent magnet direct current motor comprising:

a permanent magnet stator including at least one permanent magnet;

a rotor including a rotor shaft, an armature core mounted on the shaft and having a plurality of poles, an armature winding wound about the poles, and a commutator mounted on the shaft adjacent one end of the armature core and connected to lead wires of the armature winding, the rotor being journaled in bearings and located confronting the stator; and

a speed sensor;

wherein the speed sensor is a coil of conductive material located in the air gap between the permanent magnet and the armature core.

2. A motor according to Claim 1, wherein the coil is a single turn coil fixed to a surface of the magnet facing the armature core.

3. A motor according to Claim 2, wherein the coil is a single turn coil in the form of a long narrow "U" extending substantially in the axial direction of the motor.

4. A motor according to any one of the preceding claims, wherein terminals of the coil are located on an axial end surface of the magnet.

5. A motor according to any one of the preceding claims, wherein terminals of the coil mate with resiliently deformable fingers extending from the motor end cap.

6. A motor according to any one of Claims 1 to 4, wherein terminals of the coil mate with spring biased terminals fixed to the motor end cap.

7. A motor according to any one of the preceding claims wherein the coil is laterally centred on the surface of the magnet.

8. A motor according to any one of claims 1 to 6, wherein the coil is located on the surface of the magnet in close proximity to a lateral edge of the magnet.

9. A motor according. to any one of the preceding claims wherein the speed sensor further comprises a second single turn coil connected across the terminals of the first coil and located adjacent thereto but circumferentially spaced therefrom.

10. A motor according to claim 9, wherein the first and second coils have a common terminal.

11. A motor according to claim 9 or claim 10, wherein the first and second coils have a common portion.

12. A motor according to claim 9, wherein the first and second coils are substantially U-shaped and have a common leg.

13. A motor according to claim 12, wherein the first and second coils form a long narrow W-shaped pattern.

14. A motor according to any one of the preceding claims wherein the or each coil has a circumferential width with the same order of magnitude as the circumferential width of the gap between adjacent poles of the armature core.

15. A permanent magnet direct current motor substantially as hereinbefore described with reference to the accompanying drawings.

Abstract

A permanent magnet direct current motor 10 has a permanent magnet stator with at least one permanent magnet 14. The magnet 14 faces poles of an armature core 26 across a small air gap. A speed sensor 12 is located in the air gap for detecting rotation of the armature core. The speed sensor 12 is a single turn coil fixed to a surface of the magnet 14 facing the armature core. Terminals 38 of the coil are located on an axial end surface of the magnet and mate with resiliently deformable fingers or spring biased terminals 36 fixed to the motor end cap 20.

Figure 1

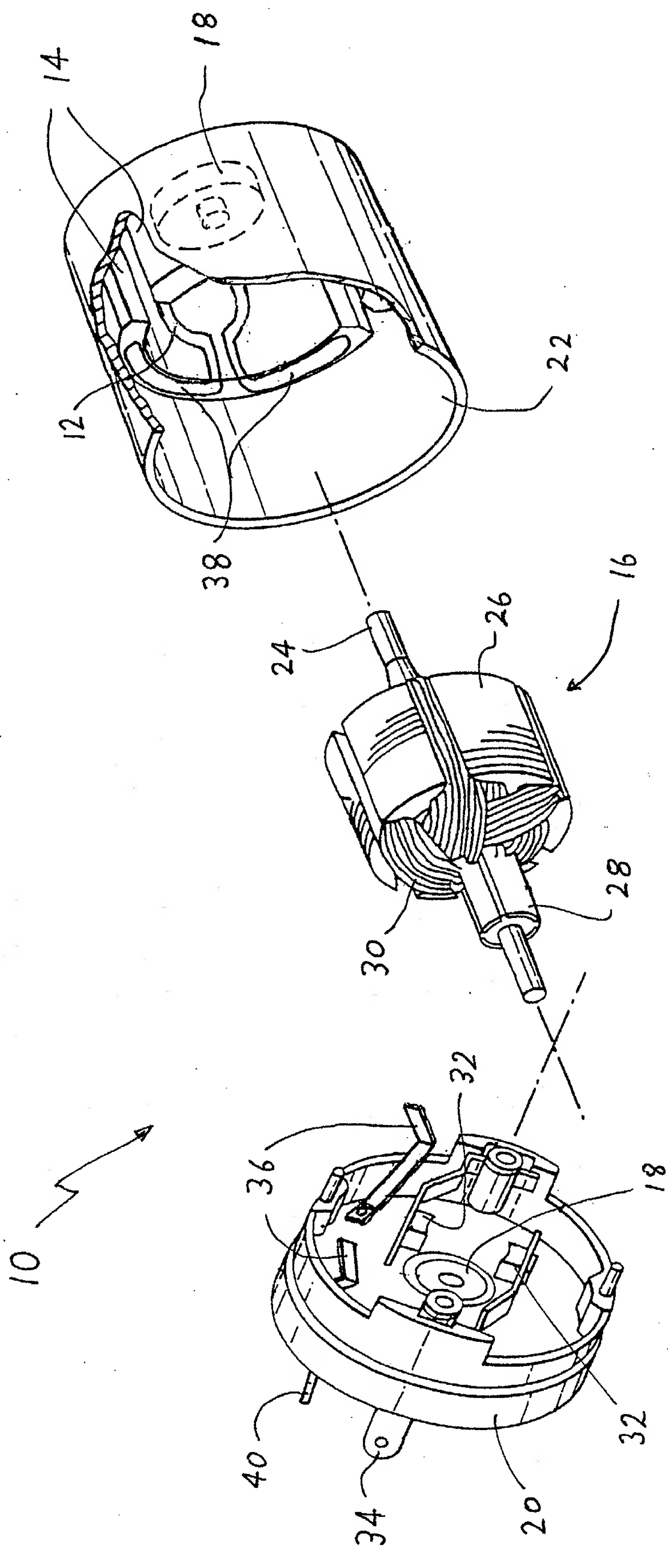

FIG. 1

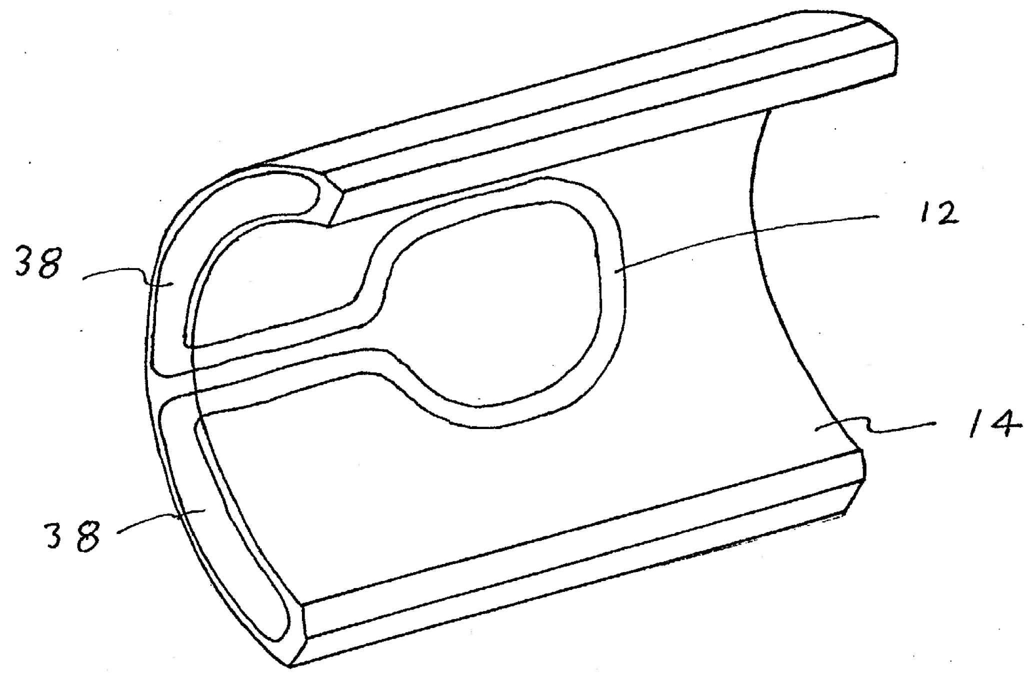

FIG. 2

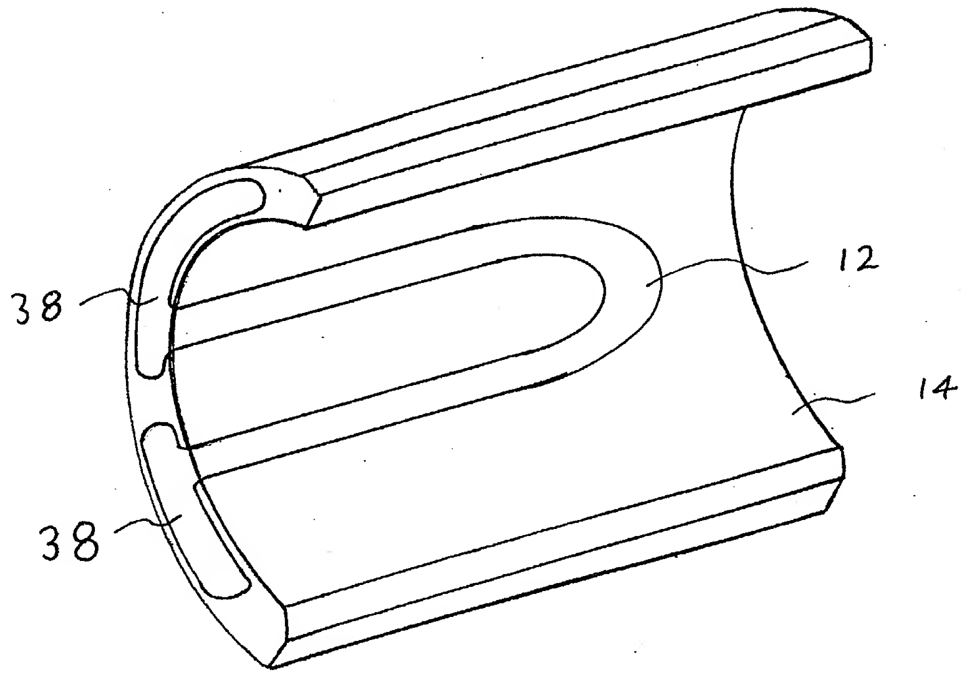

FIG. 3

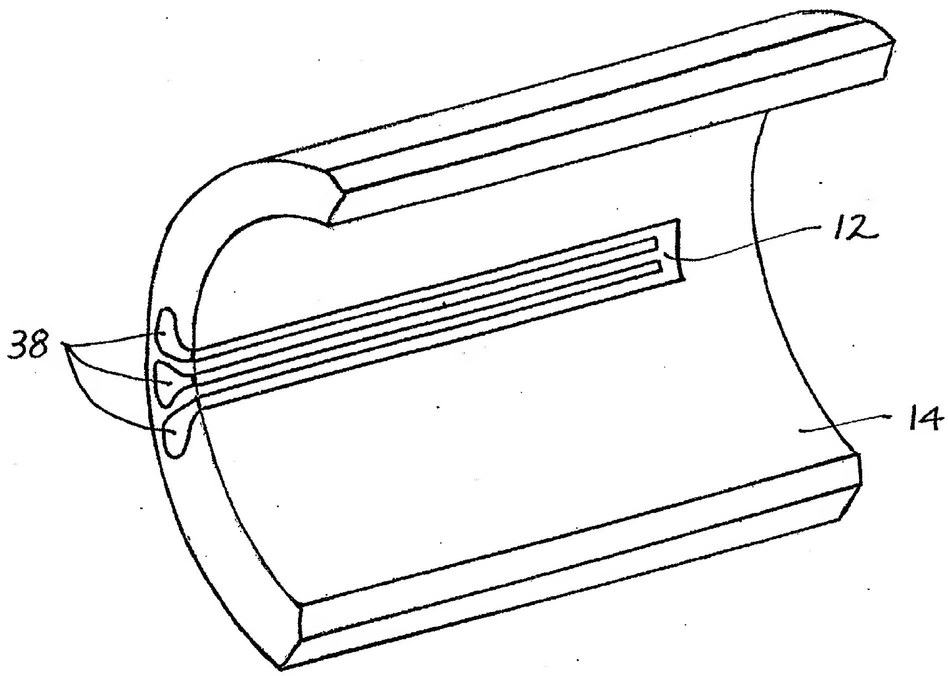

FIG. 4